

# Understanding pH

**Directions:** Use specific examples to demonstrate each of the following learning goals. You will use the following simulator to do so. Complete all work on a separate sheet of paper. This is due completed by 1May 2017.

<https://phet.colorado.edu/en/simulation/legacy/ph-scale>

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Objectives.

1. Determine if a solution is acidic or basic using
  - a. pH
  - b.  $H_3O^+/OH^-$  ratio (molecular size representation of just the ions in the water equilibrium)
  - c. Hydronium/Hydroxide concentration
2. Relate liquid color to pH.
3. Predict if dilution and volume will increase, decrease or not change the pH
4. Organize a list of liquids in terms of acid or base strength in relative order with supporting evidence.
5. Write the water equilibrium expression. Describe how the water equilibrium varies with pH.

## Student directions *pH scale* activity 1: Introduction to pH

Run the simulation

<https://phet.colorado.edu/en/simulation/legacy/ph-scale> , or

<https://phet.colorado.edu/en/simulation/ph-scale>

and work through the following questions to help you understand pH. **Use Complete Sentences for the questions!!!**

1. First explore the various liquids and complete the table below. For the acid/base column, indicate whether the solution is closer to the acid end of the scale or the base end.

Liquid	pH	acid/base	$H_3O^+$ concentration	$OH^-$ concentration
coffee				
drain cleaner				
soda pop				
water				
milk				
blood				
beer				
hand soap				
spit				
battery acid				
vomit				

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2. How is the pH related to whether it is an acid or a base?
3. Go back to the simulation and pick custom liquid. Slide the pH arrow up and down and watch what happens to the level of hydronium and hydroxide ions. As you slide the arrow down, which ion shows an increase in its concentration? Notice that the larger the negative exponent, the smaller the concentration. As you slide the arrow up, which ion concentration increases?
4. So acids have a greater concentration of which ion and bases have a greater concentration of which ion?
5. Complete the following sentences. “When pH is low, the liquid is a(n) \_\_\_\_\_ and the concentration of hydronium ions is \_\_\_\_\_.” “When pH is high, the liquid is a(n) \_\_\_\_\_ and the concentration of hydronium ions is \_\_\_\_\_.
6. Compare the concentration of hydronium ions to the concentration of hydroxide ions for water. What do you notice about the concentrations? How would you classify water in terms of an acid or a base?
7. using your calculator enter the  $[\text{H}_3\text{O}^+]$  concentrations for each of the liquids below (recall that for scientific notation you punch in the number then punch the “Exp” button and “+/-” button then the exponent number) Fill in the table below.

Liquid	pH	log of $\text{H}_3\text{O}^+$ concentration
drain cleaner		
hand soap		
blood		
spit		
water		
milk		
coffee		
beer		
Soda pop		
vomit		
battery acid		

8. How are the pH and log of the concentration of hydronium ions related?
9. Look at your table in #1. Coffee has a pH of 5 and battery acid has a pH of 1. How much more acidic is battery acid than coffee? To determine this, open your calculator on your computer again and divide the concentration of hydronium ions in battery acid by the concentration of hydronium ions in coffee. **Show your work below** and then write a sentence indicating how much more acidic battery acid is.

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10. Notice that there are 4 pH units between battery acid and coffee (pH 1 vs pH 5). Battery acid is 10,000 times as acidic as coffee. 10,000 can be written as  $10^4$ . Recall that pH is defined as  $-\log$  of the concentration of Hydronium ions and log is related to the exponent on the 10. So if there are 4 pH units between the liquids, one liquid is  $10^4$  times more acidic than the other liquid. Now let's practice that...how much more acidic is vomit than coffee? Show your work below.

11. Okay, now that you understand what pH is, let's investigate what affects pH. Go back to the simulation and pour a 1L of milk. Check out the pH. Now decrease the volume of milk to 0.5L and look at the pH. Play with several liquids to see if there is a pattern to the relationship between the volume of the liquid and the pH. In a good sentence, indicate the relationship between the volume of a liquid and its pH.

12. Now investigate the concentration of a liquid and its pH.

a) Using milk again, pour a liter of milk and check the pH.

What is it? \_\_\_\_\_

b) Decrease the volume of milk to 0.5 L and then add enough water to make it one liter. You have just diluted the concentration of milk so that it is half as concentrated as the original solution.

What is the pH now? \_\_\_\_\_. Is it more or less acidic? \_\_\_\_\_

c) Reset the simulation. Decrease the volume to 0.25 L and add water until the volume is 1 L again. You now have diluted the milk to just 25% the original concentration. What is the new pH? \_\_\_\_\_ Is it more or less acidic than when the solution is 50% dilution? \_\_\_\_\_

In a good sentence, describe what happens to the pH as you dilute the concentration of the solution.